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Proceedings of the Pacific regional peer review on the Update to the assessment framework for Goose Barnacles (*Pollicipes polymerus*)

**June 14-15, 2016
Tofino, British Columbia**

Chairperson and Editor: Janet Lohead

Fisheries and Oceans Canada
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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting of June 14-15, 2016 in Tofino, B.C. The RPR was held in response to a request from DFO Resource Management and First Nations to update an assessment protocol for the commercial harvest of Goose Barnacles specifically within Clayoquot Sound, on the West Coast of Vancouver Island in BC.

A Working Paper, that updates a general Assessment Framework for Goose Barnacles (Ca?inwa¹; *Pollicipes polymerus*) in waters off the West Coast of Canada developed by Lauzier in 1999, was presented. The update incorporates a revised survey methodology and analytical procedures for estimating Goose Barnacle bed area and biomass with the inclusion of Local Ecological Knowledge (LEK). New analytical procedures using bootstrapping methodology for quantitatively estimating Goose Barnacle biomass and an LEK method for estimating biomass was evaluated and proposed. The updated Assessment Framework explores the concept of using harvest area closures as an alternative to a biologically-based provisional Limit Reference Point (LRP) and an Upper Stock Reference (USR).

In-person and telephone participation included Fisheries and Oceans Canada (DFO) staff from the Science Sector and Fisheries Management, as well as external participants from First Nations and a Non-Governmental Organization.

The conclusions and advice resulting from this review will be provided in the form of one Science Advisory Report.

The Science Advisory Report and supporting Research Document will be made publicly available on the [Canadian Science Advisory Secretariat \(CSAS\) website](#).

¹ Ca?inwa is the Nuu-chah-nulth word for Goose Barnacles.

Compte rendu de l'examen régional par des pairs du Pacifique sur la Mise à jour du cadre d'évaluation du pouce-pied (*Pollicipes polymerus*)

SOMMAIRE

Le présent compte rendu résume les discussions et les principales conclusions de la réunion régionale d'examen par des pairs du Secrétariat canadien de consultation scientifique (SCCS) de Pêches et Océans Canada (MPO) qui a eu lieu les 14 et 15 juin 2016 à Tofino, en Colombie-Britannique. Cet examen régional par des pairs a été réalisé en réponse à une demande de la Gestion des ressources du MPO et des Premières Nations concernant la mise à jour d'un protocole d'évaluation pour la récolte commerciale du pouce-pied, en particulier dans la baie Clayoquot, le long de la côte Ouest de l'île de Vancouver, en Colombie-Britannique.

Un document de travail, élaboré par Lauzier en 1999 et mettant à jour un cadre général d'évaluation du pouce-pied (Caʔinwa²; *Pollicipes polymerus*) dans les eaux au large de la côte Ouest du Canada, a été présenté. Cette mise à jour comprend une méthode de relevé révisée et des procédures analytiques permettant d'estimer la superficie du gisement du pouce-pied et sa biomasse en intégrant les connaissances écologiques locales (CEL). De nouvelles procédures analytiques s'appuyant sur la méthode de bootstrap ont été élaborées pour estimer, de façon quantitative, la biomasse du pouce-pied et une méthode de CEL visant à estimer la biomasse a été évaluée et proposée. Le cadre d'évaluation révisé permet d'examiner le concept d'utilisation des fermetures des zones de récolte à titre de solution de rechange à un point de référence limite provisoire fondé sur la biologie et à un point de référence supérieur.

Les participants, en personne et au téléphone, incluaient des employés du Secteur des sciences et de Gestion des pêches de Pêches et Océans Canada (MPO), ainsi que des représentants des Premières Nations et d'une organisation non gouvernementale.

Les conclusions et avis découlant de cet examen seront présentés sous la forme d'un avis scientifique.

L'avis scientifique et le document de recherche à l'appui seront rendus publics sur le site Web du Secrétariat canadien de consultation scientifique (SCCS).

² Caʔinwa est le mot Nuuchah-nulth qui signifie « pouce-pied ».

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) meeting was held on June 14-15, 2016, in Tofino, British Columbia to review a working paper which updates a general Assessment Framework for Goose Barnacles (Caŋinwa¹, *Pollicipes polymerus*) in waters off the West Coast of Canada developed by Lauzier in 1999 (Lauzier 1999).

The Terms of Reference (TOR) for the science advice (Appendix A) were developed in response to a request for advice from Fisheries Managers and First Nations to update an assessment protocol for the commercial harvest of Goose Barnacles specifically within Clayoquot Sound, on the West Coast of Vancouver Island in British Columbia. Notifications of the science review and conditions for participation were sent to various representatives with relevant expertise in the subject area, including internal (DFO Science, Fisheries and Aquaculture Management) and external (First Nations, Non-Governmental Organizations) representatives. Participants and their affiliations are provided in Appendix B.

The following Working Paper was prepared and made available to meeting participants prior to the meeting:

Gagne, A., Picco, C., Rutherford, D. and J. Rogers. 2016. Update to the assessment framework for Goose Barnacles (Caŋinwa; *Pollicipes polymerus*) incorporating Local Ecological Knowledge and advancements in technology in Clayoquot Sound off the West Coast of Canada. CSAP Working Paper 2014INV02.

The meeting was called to order by Chair Janet Lohead. Andrew Jackson, Tla-o-qui-aht Fisheries Manager, welcomed participants to Tla-o-qui-aht traditional territory. This was followed by a round of introductions, housekeeping items and an overview of the agenda (Appendix C). Kate Rutherford and Brenda Waddell were identified as the rapporteurs for the meeting. The Chair reviewed the role of CSAS in the provision of peer reviewed advice, and gave a general overview of the CSAS process. The Chair discussed the role of participants, the purpose of the various RPR publications [Science Advisory Report (SAR), Proceedings, and Research Document], and the definition and process around achieving consensus on decisions and advice. Participants were reminded that everyone at the meeting had equal standing and everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice.

Participants were informed that Tammy Norgard (Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC) and Dr. Andrew Day (Vancouver Aquarium Marine Science Centre, Vancouver, BC) had been asked before the meeting to provide detailed written reviews for the Working Paper. Participants were provided with copies of the written reviews.

The conclusions and advice resulting from this review will be provided in the form of a Research Document and a Science Advisory Report providing advice to Fisheries and Aquaculture Management and First Nations on an updated assessment framework for Goose Barnacles on the west coast of Canada. The Science Advisory Report and supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

PRESENTATION OF WORKING PAPER

Alex Gagne began the presentation of the working paper with the Terms of Reference (Appendix A) for the paper. She described the distribution and biology of Goose Barnacles and emphasized the term "harvestable biomass". "Harvestable biomass" is based on size of the organisms, accessibility for harvest, and ability for live removal.

She also described Local Ecological Knowledge (LEK) which is based on the experience of the harvester; harvesters have developed and honed their visual skills to estimate the amount of harvestable product. Their knowledge is rooted by location, i.e. experience in their traditional territory.

Alex described the existing assessment framework based on the work of Lauzier (1999) and moved on to describe the updates that were made for the framework proposed in this working paper. These updates included the new GPS methodology for measuring Goose Barnacle bed area, calculation of biomass estimates from quadrats, the relationship of estimated total biomass to LEK estimates of harvestable biomass with the purpose of using the relationship to get total biomass estimates of unsurveyed rocks, and the proposal to use potential habitat as provisional reference points.

Alex then went over the results: bed area measurements, distribution of quantitative biomass estimates and resulting decision table, and the relationship between LEK harvestable to total biomass.

She also noted that because the Goose Barnacle fishery is data-limited it is difficult to develop reference points to be compliant with the Precautionary Approach (PA) (DFO 2009). The authors proposed the use of Goose Barnacle potential habitat as a proxy, noting that currently 72% of potential barnacle habitat is in park reserves and not subject to harvest. This creates a significant source of refugia. The authors propose 20% of the area as the Limit Reference Point (LRP) and 40% of the area as the Upper Stock Reference (USR). The 72% of area that is not currently harvested indicates that the stock is in the healthy zone.

Alex continued by comparing the old and new methods for calculating bed area. She outlined some of the sources of variability for measurement which was a reason for presentation of probabilities in decision tables. The harvest rate of 7.5% was taken from Lauzier (1999).

Alex gave the range of LEK estimates of harvestable biomass to total biomass. On average, over the six rocks with both estimates, LEK harvestable biomass represented 4.6% of the estimated mean total biomass, which she pointed out, is less than the range of 10-20% estimated by Day in 2005.

Alex also outlined the benefits of LEK and the melding of quantitative estimates and LEK, such as supporting the estimation of Goose Barnacle populations on a rock-by-rock basis which is the proponent's preferred assessment method. It was also felt that management at this scale is sustainable.

She also outlined some data limitations, particularly the use of the Gulland model which was relied on by Lauzier (1999). There haven't been any data collected to refine growth, natural mortality, harvest rate, or age. She also noted that there was subjectivity involved in the bed mapping.

POINTS OF CLARIFICATION

The Chair asked the room if there were any points of clarification.

There was a question on whether the harvestable/marketable size could change over time, e.g., based on some factor such as price. The authors answered that in the past, the market had a specific size that they wanted. Now the North American market is not as familiar with the product and isn't as clear on what size is wanted. Harvesters know what size is best. The harvestable size is similar to that for Spanish barnacles.

Another participant asked for clarification on why the authors chose the 50% probability for comparison to LEK. The authors said that it is usual for managers to lean towards the midpoint. They admitted that it was not well explained in the paper and that it would be improved.

A further question was asked on how the authors factored varying tide heights into the analyses when measuring bed areas. The authors said that tide heights could be no higher than three feet when measurements were made.

A participant asked whether Goose Barnacles are subject to Paralytic Shellfish Poisoning (PSP). The authors said that no, they are not, and that the Department of Fisheries and Oceans had worked with the Canadian Food Inspection Agency (CFIA) to have them categorized by their filtering mechanisms, which are most similar to crabs, and which are also not subject to PSP.

There was a question on the accuracy of the GPS. The authors replied that the accuracy was 0.5 metres.

WRITTEN REVIEWS AND COMMITTEE DISCUSSIONS

In advance of the meeting, written reviews were solicited from two individuals who are knowledgeable in the area: Tammy Norgard (Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC) and Dr. Andrew Day (Vancouver Aquarium Marine Science Centre, Vancouver, BC). The reviewers felt the paper was very well written and their full reviews are given in Appendix D and E.

REVIEWER COMMENTS AND QUESTIONS

A reviewer commented that they would like to see more recent biomass estimates using the quadrat method and asked if there were plans to do any more surveys. The authors said that more biomass estimates were obtained from two recent quadrat surveys, but they were not incorporated into the paper.

A reviewer noted that the presentation clarified the bootstrapping method and that the authors would need to improve the text in the working paper. The reviewer also suggested removal of the words "an alternate assumption is that densities among beds on the same rock are highly variable" from p. 12, Discussion 3rd paragraph. The authors agreed to do so.

A reviewer asked that the authors explain the calculation of LEK in greater detail, specifically the derivation of the 21.7 value in the equation, and suggested using the second equation presented in Tammy Norgard's written review. The authors said they would explain the derivation of the 21.7 value more thoroughly in the paper, especially as the value could change over time. They also agreed that the second equation that Tammy Norgard proposed (with some slight modifications proposed by the participants) was the best one to use.

A reviewer was intrigued to see the use of area as a proxy for virgin biomass in the proposed provisional reference points and asked if there were any other examples of this in the literature. The authors agreed to look further into the literature and to add references, if possible.

One of the reviewers said that they would like to see the uncertainty of bed measurements incorporated into the biomass estimates. The authors explained that all measurements were used in the bootstrapping, not just the means of bed area, and that they will clean up the text in the working paper to explain the methodology more thoroughly.

A reviewer then noted that the authors used the 7.5% harvest rate (same as Lauzier 1999) and that she would have liked to have seen an analysis that provided a range of harvest rates and mortality estimates. The authors explained that they just carried this over from Lauzier (1999) and emphasized that this is an assessment framework and not a stock assessment. When a stock assessment takes place, then that would be the time to look at options to address and evaluate ranges of harvest rates and mortality estimates.

One of the reviewers then asked about the product remaining on the rocks. The authors explained that this is an estimate of the remaining *harvestable* amount, not a total biomass estimate. They agreed to clarify this in the paper.

It was mentioned by a reviewer that the term "integrity of knowledge" (Section 2.3, pg. 4) required more explanation. The authors agreed to explain this more fully and noted that there is a reference that can be cited.

A reviewer asked whether the framework was specific to Clayoquot Sound, and if not, then the paper should refer to other areas by name. The authors said that the framework could apply to other areas but that it would need some customization. They said they will add some wording to that effect in the paper.

One of the reviewers felt that multiple methods for biomass estimation were not necessary and suggested that only LEK be used. The authors explained it would be possible to use only LEK and bed area estimation, but that the quantitative method added value to the overall framework.

A reviewer questioned the validity of using standard formulas and generalized estimates of the mortality rate and the harvest rate. The reviewer noted that the beds are in highly dynamic environments. The authors acknowledged that they used the same mortality and harvest rate estimates as Lauzier (1999) and, due to the paucity of biological information for Goose Barnacles, there was very little new information available to update the estimates. The authors explained that the new framework addresses the fact that the beds are dynamic – in the methods, surveyors go back and reassess the beds and incorporate LEK. With respect to the 7.5 % harvest rate from Lauzier (1999), the authors explained that this value falls into the range of variability seen in the estimates of LEK harvestable amounts, and that it applies overall, not to each rock.

One of the reviewers had comments on the self-regulating nature of the fishery, specifically, that there are direct incentives such as size and regeneration time, to not overfish. It was asked why pre- and post-harvesting biomass estimates are needed, as this may erode confidence of fishers in our belief of LEK. The authors noted that the self-regulating nature works when the fishery is small but may not if it expands.

A reviewer liked the Precautionary Approach discussion in the paper; however, they had a point on the scale of the approach and felt it should be the west coast of Vancouver Island, not just Clayoquot Sound. The authors noted that the idea of scale had been discussed in the morning. The authors then described the idea of layered precaution: precaution based on area harvested versus unharvested, plus the percent of each rock that was harvested, plus the number of rocks

harvested out of the total. This highlights how precautionary the fishery currently is. The authors noted that PA compliance was a focus in the working paper and that DFO requires the setting of an Upper Stock Reference (USR).

A reviewer then outlined the concept of thresholds for each rock, which were used in an adaptive management system in the work that had been conducted in 2003-2005 (Day 2012). The authors said that a decision was made to separate assessment and management. What the reviewer described is how the fishery is being managed now. This working paper is just looking at the assessment of biomass.

A reviewer commented that in the paper it appears as though the authors recommended a harvest rate of 7.5%. The reviewer questioned - isn't this management? The reviewer asked if a threshold was set on 7.5%? The authors explained that there is a need for a predefined harvest control rule and that they carried over the 7.5% from work by Lauzier (1999). It was not meant to be taken as a recommendation; it is a point estimate and there is lots of uncertainty. The authors agreed to clarify this in the working paper.

The reviewers thanked the authors and added that it was great to see this collaboration between First Nations and Fisheries and Oceans Canada.

COMMITTEE COMMENTS AND QUESTIONS

The Chair invited the participants to provide key topics to help guide group discussion.

The following list was developed:

1. Reserve area (refugia) as provisional reference points
2. Relationship between LEK and biomass
3. 7.5% harvest rate
4. Emphasize how conservative the harvest rate actually is
5. How does information relate to other harvest areas?
6. Other technology, e.g., drones, to estimate bed area
7. Studies to look at post-harvest recovery – LEK elements and quantitative

Reserve area (refugia) as provisional reference points

The authors provided further background on this concept. The PA graph was displayed and explained. Because the fishery is data-limited, the paper used area measurements of potential Goose Barnacle habitat from the work of Howes et al. (2001), with total potential habitat area being akin to B_0 (virgin biomass). The Limit Reference Point (LRP) is set at 20% B_0 (i.e. area; below this is the critical zone), the Upper Stock Reference (USR) is set at 40 % B_0 (between 20 and 40% = cautious zone), and above the USR is the healthy zone.

There was a question about whether rocks in the refugia (or unharvested areas) would just stay the same over time. It was explained that at the present time, there are more rocks not in the park refugia which are not currently being harvested, representing an opportunity for more harvesting sites. However, there is also a desire to keep the option of potentially harvesting within the park reserve open for future discussions, because the park area is within the traditional territories of the Tla-o-qui-aht First Nation.

Participants discussed the scale of the approach, and whether there is enough knowledge about larval distribution and whether the park was actually supplying larvae. It was noted that Goose Barnacle is treated as a coastwide stock. Larval dispersal is believed to occur along the west coast of Vancouver Island, however there is uncertainty around many things such as larval flows and source/sink metapopulations.

The participants discussed the bio-band data used to estimate total potential habitat, and questioned how much of the reserve area is actually occupied, pointing out that not all potential habitat is occupied. There is a relationship between potential, actual and harvestable habitat that has not been described or quantified. The room agreed that the uncertainties around the use of the bio-band data to estimate total available habitat should be added to the uncertainties section of the paper. The authors agreed.

Participants wondered whether there would be a desire to use this concept for other invertebrate fisheries. Participants felt that the refugia approach was appropriate as an interim measure in the case of Goose Barnacle in the Clayoquot Sound area due to the sessile nature of the organism, the data limitations associated with estimating population parameters, the small spatial scale on which it is being applied, and in recognition that the refugia are spatially integrated into the current harvest area, meaning that larval connectivity is likely. It was agreed that these points should be outlined in the working paper as well as in the Science Advisory Report.

Relationship between LEK and quantitative biomass estimates

A participant asked about the variability amongst people interviewed for the LEK estimates of biomass. There was a question about the number of knowledge holders interviewed and their credentials (why they are an expert), noting credentials may change as new people come into the fishery and experienced people go. The participants felt that it was important that the number interviewed be included in the paper so readers could gauge sample size and see the influence, or any bias, of individuals. The authors agreed to add this to the paper. The authors noted that each interview was independent and they explained that experts are those that have been led or taught by experienced people within the community – the knowledge is passed within the community, e.g., father to son. The results were usually similar among experts but the authors did remove a small number of outliers. The authors agreed to add more information to the paper on how the outliers were identified and if they were removed. There was discussion on whether a weighting factor, for example the number of years of experience, should be incorporated into the estimates and the room felt that this may be an approach to explore in the future.

Use of 7.5 % harvest rate

The authors explained that the 7.5% harvest rate was calculated by Lauzier using the variable calculations for growth based on the von Bertalanffy, Hoenig, and Gulland models. There hasn't been any new work so the authors inherited the same models and the same harvest rate from the 1999 Lauzier framework. They noted that the 7.5% harvest rate lies within the LEK range of values (0.8 to 15%) and that it is less than the Day (2012) estimate of 10-20%. The authors explained that the 7.5% harvest rate was derived from the 50% probability value; it would be a different harvest rate if it was derived from a different probability value, e.g., 10%. The authors assured the room that the working paper would describe that the 7.5% harvest rate refers to the population overall (Clayoquot Sound), and that there is some flexibility in harvest per rock.

Very conservative harvest of potential biomass

The participants agreed that the fishery is currently low risk and discussed whether they wanted the working paper to reflect how precautionary the fishery is. The authors said that reflecting fishery dynamics is not part of the Assessment Framework. It was decided that the Proceedings would capture that the room agreed the fishery is currently operating in a low-risk way, however current execution of the fishery is not within the scope of the assessment framework paper.

How does the information in the framework relate to other harvest areas?

The authors explained that this framework paper is specific to Clayoquot Sound because this is the area of interest to the proponents. In the late 1990s and early 2000s there was harvesting north (Kyuquot Sound) and south (Barkley Sound) of Clayoquot Sound. A portion of the 395 quadrats used in the quantitative estimate of biomass come from these other sounds. The participants agreed that the framework could be applied to other areas. At the very least, that would require mapping of the beds in the new areas and there would be a need to recalculate the relationship between LEK and quantitative estimates of biomass for each sound.

After going through the identified key topics for group discussion, the Chair asked if there were any further topics for discussion. A participant asked whether the authors had looked at post-harvest recovery, i.e. post-harvest growth, regeneration and/or recolonization. A Goose Barnacle harvester noted that it depends on the rock, time of year, and the conditions (e.g. swell). If you break the strength of the colony by taking part out it may be less stable in seasons with strong wave action - some rocks have never completely recovered. LEK includes knowledge of how long it takes for a rock to recover. It was noted that Goose Barnacle mortality can also be caused by random and sporadic events, not related to harvest, such as logs hitting and wiping out beds. The room agreed that it should be noted in the working paper, SAR and Proceedings that research on Goose Barnacle harvest recovery response should be highlighted as an area for future work.

A final suggestion of adding the Nuu-chah-nulth name for Goose Barnacle (Ca?inwa) to the paper was brought forward. It would include a description in a footnote of its meaning, which is "playing in/with the waves". Everyone agreed.

The Chair then asked participants if there was consensus on the paper's acceptability. A participant moved to accept the paper with the agreed upon changes noted by the rapporteurs. There was no opposition and the paper was accepted.

Upon adjournment of the meeting, participants prepared to embark upon a field trip to several Goose Barnacle harvest rocks, compliments of T'aaq-wiihak Nations. Fifteen participants met at the 1st street dock in Tofino and boarded the Ahousaht Raider. The vessel brought participants to several Goose Barnacle harvest rocks located just outside of Tofino. The authors and a harvester pointed out the location of harvestable barnacles as well as visible 'scars' where harvest had recently taken place. Commentary was provided on how weather and tides affect the accessibility of certain rocks, as well as the logistics of accessing the harvestable barnacles once on the rocks. The tour lasted for about an hour, and then the vessel returned to Tofino. Participants were grateful for the opportunity to view the harvest rocks as it provided context and perspective to the meeting.

CONCLUSIONS AND ADVICE

The participants endorsed the following conclusions, advice and areas for future work:

1. Implement the updated assessment framework in Clayoquot Sound and potentially adapt and apply it to other areas along the coast of British Columbia.
2. Adopt the LEK method for estimating total Goose Barnacle biomass for rocks with no bed area estimates.
3. Adopt the refugia approach for provisional reference points as an interim measure.
4. Future work:

-
- Continue to conduct bed area estimation and quantitative biomass estimates for rocks harvested solely based on LEK estimates.
 - Collect data to update the relationship between LEK and quantitative biomass estimates.
 - Undertake research on Goose Barnacle harvest recovery response.
 - Continue to evaluate reference points compliant with the Precautionary Approach.

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Howes, D., Harper, J., Owens, E. 2001. B.C. Biophysical Shore-Zone Mapping System- A Systematic Approach to Characterize Coastal Habitats in the Pacific Northwest. Technical Report by Coastal and Ocean Resources, Inc., Sidney, BC for the Coastal Task Force of the Resource Inventory Committee (RIC), Victoria, BC: RIC Secretariat.

Lauzier, R.B. 1999. Framework for Goose Barnacle (*Pollicipes polymerus* Sowerby, 1833) fishery in waters off the west coast of Canada. Canadian Stock Assessment Secretariat Research Document 99/198. 24 pp.

APPENDIX A: TERMS OF REFERENCE

Update to the assessment framework for Goose Barnacles (*Pollicipes polymerus*)

Regional Peer Review Process – Pacific Region

June 14 and 15, 2016

Tofino, British Columbia

Chair: Janet Lochead

Context

A review of the biology and fisheries for goose barnacles was presented to the Pacific Science Advice Review Committee (PSARC) in 1999 and raised concerns regarding the sustainability and viability of the fishery given the paucity of information on goose barnacle abundance, distribution, and life history parameters, as well as the lack of biologically based harvest control rules (Lauzier 1999). In response to these concerns, a very general framework for goose barnacles in waters off the West Coast of Canada was prepared and presented to PSARC in 1999 (Lauzier 1999).

Various knowledge gaps relating to goose barnacles still existed at the time the Lauzier (1999) framework was developed. In response, an experimental fishery was authorized under the New Emerging Fisheries Policy DFO (2001, now superseded by 2008) to, in part, gather information and conduct studies to expand the knowledge base and further develop assessment methods.

Advances in technology and the acquisition of new equipment have provided opportunities to update the survey methodology used to estimate goose barnacle bed area. New bed area estimations, supported by local ecological knowledge (LEK), could potentially inform and refine biomass estimation and the development of conservation objectives. This work has been conducted in response to a re-invigoration of interest in the goose barnacle fishery off the west coast of Vancouver Island from five Nuu-chah-nulth First Nations. The five Nuu-chah-nulth First Nations; Ahousaht, Ehatesaht, Hesquiaht, Mowachaht/Muchalaht, and Tla-o-qui-aht have aboriginal rights to fish within their fishing territories and to sell that fish, with the exception of geoduck. The Department of Fisheries and Oceans (DFO) is working with the First Nations to accommodate and exercise their right without jeopardizing Canada's legislative objectives and societal interests in regulating the fishery.

The five First Nations took the lead and developed an updated assessment framework in collaboration with DFO. The framework is specific to Clayoquot Sound, within two of the five First Nations fishing territories, but could have potential application to other areas. The five First Nations, along with DFO Fisheries Management, have requested a Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) of the updated assessment framework. Advice arising from this CSAS RPR, will be used to inform the Nations, Fisheries Management and Science on the soundness of the updated assessment framework and will guide the goose barnacle fishery as it transitions from the Feasibility Stage (Stage 1) towards the Exploratory Stage (Stage 2) of DFO's updated New Emerging Fisheries Policy (2008).

Objectives

The following working paper will be reviewed and provide the basis for discussion and advice on the specific objectives outlined below.

Gagne, A., C. Picco, D. Rutherford and J. Rogers. 2016. Update to the assessment framework for Goose Barnacles (*Pollicipes polymerus*) in Clayoquot Sound. CSAP Working Paper 2014INV02.

1. Develop a new methodology for estimation of Goose Barnacle bed area using Trimble Handheld GPS in conjunction with GoogleEarth Pro and Local Ecological Knowledge (LEK).
2. Develop a revised methodology for estimating Goose Barnacle biomass.
3. Provide:
 - Quantitative estimates of total biomass, by harvest rock in Clayoquot Sound, in the form of decision tables.
 - An estimated sustainable harvest rate.
 - LEK estimates of biomass available for harvest.
 - Limit reference point(s) at an appropriate scale consistent with the PA policy.
4. Examine and identify sources of uncertainties in the data and methods.
5. Provide recommendations for future monitoring.

Expected Publications

- CSAS Science Advisory Report
- CSAS Research Document
- CSAS Proceedings

Expected Participation

- Fisheries and Oceans Canada (DFO) Fisheries Management, Science
- First Nations with traditional territories in Clayoquot Sound
- T'aaq-wiihak Fisheries technical staff
- Uu-a-thluk (Nuu-chah-nulth Tribal Council Fisheries Department) technical staff

References

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Lauzier, R.B. 1999b. Framework for Goose Barnacle (*Pollicipes polymerus* Sowerby, 1833) fishery in waters off the west coast of Canada. Canadian Stock Assessment Secretariat Research Document 99/198, Fisheries and Oceans Canada. Ottawa, Canada. 24 pp.

APPENDIX B: PARTICIPANTS

Last name	First name	Affiliation
Archer	Stephanie	DFO Science
Cox	Keith	Kyuquot cheklisaht
Crowley	Sabrina	Nuu-chah-nulth Tribal Council, Uu-a-thluk
David	Joe	Tla-o-qui-aht Councilor and ex-harvester
Day	Andrew	Vancouver Aquarium
Dick	Jared	Nuu-chah-nulth Tribal Council
Francis	Danielle	T'aaq-wiihak Coordinator
Gagne	Alex	T'aaq-wiihak Fisheries
Hall	Don	Nuu-chah-nulth Tribal Council, Uu-a-thluk
Jackson	Andrew	Tla-o-qui-aht Fisheries Manager
Johansen	Jeff	DFO Fisheries Management
Lochead	Janet	DFO Science (Chair)
Louie	Guy	Ahousaht Councilor and ex-harvester
MacDougall	Lesley	DFO Science
Martin	Marcel	Tla-o-qui-aht Harvester
Martin	Moses	Tla-o-qui-aht Councilor and former Chief
Norgard	Tammy	DFO Science
Oldford	Grieg	DFO Oceans Program
Parker	Guy	DFO Fisheries Management
Picco	Candace	Nuu-chah-nulth Tribal Council, Uu-a-thluk
Rogers	Juanita	DFO Fisheries Management
Rutherford	Kate	DFO Science (Rapporteur)
Rutherford	Dennis	DFO Science
Smith	Darlene	DFO Science
Waddell	Brenda	DFO Science (Rapporteur)
Webster	Andy	Ahousaht Councilor

APPENDIX C: AGENDA
Canadian Science Advisory Secretariat
Regional Peer Review Meeting (RPR)
Update to the assessment framework for Goose Barnacles (*Pollicipes polymerus*)
June 14 and 15, 2016 - Tofino, BC
Chair: Janet Lohead

DAY 1 – Tuesday, June 14, 2016

Time	Subject	Presenter
0830	Call to Order	Chair
0835	Opening Welcome by Tla-o-qui-aht	Moses Martin
0845	Introductions Housekeeping & Review Agenda CSAS Overview and Procedures	Chair
0900	Review Terms of Reference	Chair
0915	Presentation of Working Paper	Authors
1000	Points of Clarification	RPR Participants
1015	Break – coffee/tea and fruit/pastry platter provided by CSAP	
1030	Tammy Norgard's Written Review	Chair + T.Norgard & Authors
12:00	Lunch Break – catered by Tin Wis, provided by T'aaq-wiihak Nations	
1300	Andrew Day's Written Review	Chair + A.Day & Authors
1430	Break	
1445	Identification of Key Issues for Group Discussion	Chair + RPR Participants
1500	Group Discussion of Key Issues	RPR Participants
1645	Check in on progress and confirmation of topics for discussion on Day 2	RPR Participants
1700	Adjourn for the Day	

DAY 2 – Wednesday, June 15, 2016

Time	Subject	Presenter
0830	Review Agenda & Housekeeping Review Status of Day 1	Chair
0845	Group Discussion of Key Issues (Continued from Day 1)	RPR Participants
1000	Break - coffee/tea and fruit/pastry platter provided by CSAP	
1015	Group Discussion of Key Issues	RPR Participants
1045	Transit to Water Taxi Dock	RPR Participants
1100	Field trip to Goose Barnacle Harvesting Sites onboard the Ahousaht Raider	RPR Participants
1230	Lunch Break – catered by Tin Wis, provided by T'aaq-wiihak Nations	
1315	Develop Consensus on Paper Acceptability & Agreed-upon Revisions	RPR Participants
1330	<i>Science Advisory Report (SAR)</i> Develop consensus on the following for inclusion: • Sources of Uncertainty • Recommendations • Additional advice to Management (as warranted)	RPR Participants
1430	Break	
1445	<i>Science Advisory Report (SAR)</i> Develop consensus on the following for inclusion: • Sources of Uncertainty • Recommendations • Additional advice to Management (as warranted)	RPR Participants
1530	Next Steps – Chair to review • SAR review/approval process and timelines • Research Document & Proceedings timelines • Other follow-up or commitments (as necessary)	Chair
1545	Other Business arising from the review	Chair & Participants
1600	Adjourn meeting	

APPENDIX D: WRITTEN REVIEWS

ANDREW DAY, VANCOUVER AQUARIUM MARINE SCIENCE CENTRE

- Is the purpose of the working paper clearly stated?

Yes. Note that the objective stating the update is specific to Clayoquot Sound conflicts with the statement that the framework could apply elsewhere. The framework should explicitly be designed to be applied in other regions (especially of WCVI).

- Are the data and methods adequate to support the conclusions?

While I appreciate that the authors wish to retain reliance on quantitative methods, there are serious flaws in the quantitative methods originally used in the assessment of this fishery. These flaws stem from what I consider to be a misconception of the species and fishery.

My main comments are as follows:

1. Using standard formulas with generalized estimates is more guesswork than science. This is especially the case for natural mortality rates and the corresponding harvest rate, both of which appear to have little foundation in reality. This is compounded by the fact that the beds are in highly dynamic environments. Their size and composition change over time and are influenced by natural disturbances. Growth rates, natural mortality rates, recovery rates and other key factors used in quantitative methods vary significantly from rock to rock (and even within rocks) based on their orientation, exposure, topography, substrate, and other factors. Similarly, rock size, access, and proximity to human settlements influence the amount of harvest effort significantly from rock to rock. This needs to be considered if using a harvest rate approach. A rock that is visited once or twice a year is not equal to one that is visited monthly or bi-monthly.
2. For similar reasons, density and biomass might not indicate harvestable quantity, especially over time. First, as discussed, the rocks are unique due to their exposure and other factors. Based on LEK in previous fisheries, rocks with less disturbance and good growth conditions may tend to have more older individuals, while rocks with more disturbance and/or poor growth conditions may tend to have more younger ones. Second, harvesters are removing marketable size barnacles and in doing so they are grooming the beds. Over a longer period of time (as older barnacles die off), one would expect less older barnacles and more younger and marketable size barnacles. In short, proper harvesting should lead to an increased harvest over time due to the increase in marketable size barnacles. This is evidence of good harvesting practices, not bad ones. If this is not understood, a fixed (and spurious) harvest rate will erroneously curtail harvest opportunities.
3. Further, it is important to consider the self-regulating nature of the fishery. Fishermen have two direct incentives not to over harvest. First, they can only sell a certain size. Second, if they harvest too many then they will not be able to go back for extended periods. They also are severely limited by tides and accessibility. As Lauzier says, "If only 1-15% of the total biomass in a particular bed or site is suitable for harvesting, then it may be difficult to discern the effects of harvesting by comparing pre- and post-harvesting biomass estimates." This begs the question of why pre and post harvesting biomass estimates are relevant or useful.
4. If scientists and managers increase reliance on questionable quantitative methods to set harvest rates and limits, then fishermen may fish to erroneous limits rather than utilizing their direct experience and judgment. They may also lose trust in the assessment and management system, which can lead to overharvesting or other issues.

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5. Challenges in using a quantitative approach may be compounded by the fact that bed sizes may change over time. Moreover, there is likely some reality to the unexplored hypothesis regarding variability of density within a bed (based on previous LEK).
 6. The geographic method of addressing the precautionary approach requirement is good, but the authors do not go far enough in describing how precautionary the fishery actually is. First, Clayoquot Sound should not be the area benchmark. WCVI is a more appropriate area given larval dispersal to WCVI as per Lauzier. Second, harvestable biomass should be used as opposed to biomass on harvested rocks, given that 1-15% of biomass is harvestable, or "On average, over the six rocks, LEK *harvestable* biomass represented 4.6% of the estimated mean total biomass." It is almost impossible using these figures to characterize the stocks as anything but at the far end of the 'healthy' scale in terms of being precautionary.
 7. For the reasons outlined above, the biomass / density / harvest rate approach is limited in utility. In short, the fishery is much more akin to agriculture than it is to fishing. My recommendation is as follows:
 - a. Re-consider the approach in the paper. Consider instead using the approach used in the 2003-2005 fishery (which is scarcely referenced yet was highly effective, with no observed stock issues). LEK was used exclusively to set rock thresholds in 2003-2005. The approach used an adaptive management system wherein
 - i. Rock thresholds were used to close rocks
 - ii. Recovery rates were estimated and closed rocks were reopened after the recovery date.
 - iii. 3rd party (West Coast Aquatic) visual monitoring and assessments were used to verify any triggered closures and re-openings after recovery periods.
 - iv. Normally visual assessments were used before the recovery period ended to see if the rock could re-open sooner, in which case the recovery period would be adjusted. If harvesters returned to the rock after re-opening and were able to find a healthy amount of marketable barnacles, that corroborated the recovery periods. Over time, the thresholds and recovery rates were to be adjusted based on harvester behaviour, observations regarding marketable biomass available, and other factors such as observed natural mortality or other variability
 - b. Given that some rocks are more accessible and will be groomed over time, focus any quantitative or other monitoring effort on those rocks.

- Are the data and methods explained in sufficient detail to properly evaluate the conclusions?

Yes.

- If the document presents advice to decision-makers, are the recommendations provided in a useable form, and does the advice reflect the uncertainty in the data, analysis or process?

The advice includes clear recommendations and sources of uncertainty. Some of the sources of uncertainty inherent in the quantitative approach are not outlined in the section on uncertainty and should be.

-
- Can you suggest additional areas of research that are needed to improve our assessment abilities?

As above, my recommendation is to use an adaptive approach to the assessment and management of this fishery, wherein on-going adjustments to rock thresholds and recovery rates are made based on observations. For rocks that experience regular closures and re-openings, more advanced research on factors such as biomass, growth rates, natural mortality, etc. may be useful.

TAMMY NORGARD, FISHERIES AND OCEANS CANADA

Thank-you for the opportunity to comment on this paper, I believe this paper met all of the objectives listed in the TOR. Beyond a few minor editorial comments, the majority of my comments related to defining the methods a little more clearly.

I would also like to commend the authors on their work with incorporating the LEK into the document. In the discussion on page 12 in the last paragraph the author give a great explanation for why one of the biomass estimates from the LEK analysis did not lie within the bounds of the quadrat estimate. This statement was well thought out and incorporated some excellent LEK observations.

1. Is the purpose of the working paper clearly stated?

YES

2. Are the data and methods adequate to support the conclusions?

Yes, the data and methods are adequate.

I would have liked to see more current biomass estimated from the Quadrat surveys but in the future when more data come available hopefully this analysis can be looked at again.

3. Are the data and methods explained in sufficient detail to properly evaluate the conclusions?

Biomass estimates of –Quadrat Method

- I am having a little trouble following the steps in this method. I believe all the steps 1 to 8 are for quadrats and beds on the same rock. If this is true then in Step on I would remove the word *Randomly* and replace it with 'For each of the 19 rocks where density ...etc'. If I do not understand this correctly please try to clarify this for me in the presentation at the meeting.

Page 12 Discussion 3rd paragraph the authors wrote that "an alternate assumption is that densities among beds on the same rock are highly variable". I suggest removing this statement as you have given good deal of evidence that this statement is not needed. If you keep this statement then I would like to see a recommendation to look at this in the future.

LEK Method for Biomass estimate

Equation 4 – I had a very hard time understanding where the 21.7 constant came from in this equation so a more detailed explanation could be added to clarify this. OR I would suggest using a different equation to include the average Proportion LEK:ETB in this case 4.6. Below are two suggested equations

LEK estimate * (100/(4.6))= ETB

Or

LEK estimate *(100/(Average Proportion of LED:ETB at 50%) = ETB

-
1. If the document presents advice to decision-makers, are the recommendations provided in a useable form, and does the advice reflect the uncertainty in the data, analysis or process?

Yes there is advice is provided in a usable form and does reflect the uncertainty. The authors have provided Table 4 with range of probabilities in the biomass estimates.

I am very excited about the idea that PA policy can be met by reserving area. I would like to see a reference to a fishery of where this might have been done before... if possible.

2. Can you suggest additional areas of research that are needed to improve our assessment abilities?

I would like to see a way to include the uncertainty in bed area incorporated into the analysis of biomass estimate in the future. I like how the survey team completed multiple maps of same beds. It is the differences in these bed estimates that I would like to see somehow incorporated into the uncertainty in the biomass estimates.

A 7.5% harvest rate was used in this paper and it was selected because nothing as has changed since the last paper. I realize the authors choose to provide a range of biomass estimates for the managers to choose from. I would have liked to have also see an analysis that provided a range of harvest rates and mortality estimates.

In the last paragraph of the Discussion the authors state the Harvesters provide a biomass estimate for the product remaining on the rock. This is another form of LEK data input that if collected in a structure way could potentially be used in analysis of Biomass. This data and analysis could be explored in the future.

Editorial comments

Figure 1 – add area 124 to map.

Page 4 – Section 2.3 In LEK – Please define integrity of knowledge – really like this concept and think a little more explanation will make it clearer.

Page 7 – Section 4.1 last sentence in the first paragraph refers to Figure 3 and I believe it should refer to figure 5

Page 9 – Add the R code in to the appendix from the Biomass estimates

I hope my comments are helpful and look forward to discussing them.

Thanks! Tammy Norgard

APPENDIX E: ABSTRACT OF WORKING PAPER

This Goose Barnacle Framework updates a general Framework for Goose Barnacles (*Pollicipies polymerus*) in waters off the West Coast of Canada developed by Lauzier in 1999. The update incorporates a revised survey methodology and analytical procedures for estimating goose barnacle bed area and biomass with the inclusion of Local Ecological Knowledge (LEK). Bed area can now be mapped and estimated much more efficiently using advances in Global Positioning System (GPS) technology and Google Earth Mapping Software. New analytical procedures using bootstrapping methodology are proposed for quantitatively estimating Goose Barnacle biomass. In addition an LEK method for estimating biomass is evaluated and proposed. The new methodologies are documented, and results of recent surveys using the new methodologies are presented.

Goose Barnacle bed area for six rocks in Clayoquot Sound was surveyed using GPS. Replicate surveys were conducted and variability between surveyors averaged 12.3%. Goose Barnacle density data sampled from 19 rocks between 2000 and 2003 were used in the quantitative estimates of biomass for the six rocks with GPS derived bed areas. Densities ranged from 0 to 39 kg/m² and averaged 7 kg/m². Biomass estimates are presented along with probabilities in a decision table form.

Local Ecological Knowledge is incorporated into several aspects of the assessment framework. LEK is used to estimate the *harvestable* biomass which takes into consideration size range for market, accessibility and availability. LEK *harvestable* biomass was compared to quantitative estimates of total biomass. LEK *harvestable* biomass was found to represent 4.6% of the quantitatively estimated mean biomass for the six rocks surveyed using GPS.